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SYNTHESIS, CHARACTERIZATION AND ANTI MICROBIAL ACTIVITY OF SILVER NANOPARTICLES BY USING CHEMICAL SOURCES

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ABSTRACT

Silver has been recognized as a nontoxic, safe inorganic antibacterial/antifungal agent used for centuries. Silver demonstrates a very high potential in a wide range of biological applications, more particularly in the form of nanoparticles. Environmentally friendly synthesis methods are becoming more and more popular in chemistry and chemical technologies and the need for ecological methods of synthesis is increasing; the aim is to reduce polluting reaction by-products. Another important advantage of green synthesis methods lies in its cost-effectiveness and in the abundance of raw materials. During the last five years, many efforts were put into developing new greener and cheaper methods for the synthesis of nanoparticles. The cost decrease and less harmful synthesis methods have been the motivation in comparison to other synthesis techniques where harmful reductive organic species produce hazardous by-products. This environment friendly aspect has now become a major social issue and is instrumental in combatting environmental pollution through reduction

or elimination of hazardous materials. This review describes a brief overview of the research on green synthesis of silver nanoparticles using natural sources.

INTRODUCTION OF NANOPARTICLES

A nanoparticle or ultrafine particle is a particle of matter 1 to 100 nanometres (nm) in diameter. The term is sometimes used for larger particles, up to 500 nm, or fibers and tubes that are less than 100 nm in only two directions. At the lowest range, metal particles smaller than 1 nm are usually called atom clusters instead.

Nanoparticles are distinguished from microparticles (1-1000 µm), "fine particles" (sized between 100 and 2500 nm), and "coarse particles" (ranging from 2500 to 10,000 nm), because their smaller size drives very different physical or chemical properties, like colloidal properties and ultrafast optical effects or electric properties.

Being much smaller than the wavelengths of visible light (400-700 nm), nanoparticles cannot be seen with ordinary optical microscopes, requiring the use of electron microscopes or microscopes with laser. For the same reason, dispersions of nanoparticles in transparent media can be transparent,[6] whereas suspensions of larger particles usually scatter some or all visible light incident on them. Nanoparticles also easily pass through common filters, such as common ceramic candles, so that separation from liquids requires special nanofiltration techniques. nanoparticles and the influence of the method on their size and morphology.

CLASSIFICATION OF NANOPARTICLES

NPs are broadly divided into various categories depending on their morphology, size and chemical properties. Based on physical and chemical characteristics, some of the well-known classes of NPs are given as below.

1. Carbon-based NPs

Fullerenes and carbon nanotubes (CNTs) represent two major classes of carbonbased NPs. Fullerenes contain nanomaterial that are made of globular hollow cage such as allotropic forms of carbon. They have created noteworthy commercial interest due to their electrical conductivity, high strength, structure, electron affinity, and versatility (Astefanei et al., 2015). These materials possess arranged pentagonal and hexagonal carbon units, while each carbon is sp2 hybridized.

2. Metal NPs

Metal NPs are purely made of the metal precursors. Due to well-known localized surface plasmon resonance (LSPR) characteristics, these NPs possess unique optoelectrical properties. NPs of the alkali and noble metals i.e. Cu, Ag and Au have a broad absorption band in the visible zone of the electromagnetic solar spectrum.

3. Ceramics NPs

Ceramics NPs are inorganic non-metallic solids, synthesized via heat and successive cooling. They can be found in amorphous, polycrystalline, dense, porous or hollow forms (Sigmund et al., 2006). Therefore, these NPs are getting great attention of researchers due to their use in applications such as catalysis, photocatalysis, photodegradation of dyes, and imaging applications. (Thomas et al., 2015).

4. Semiconductor NPs

Semiconductor materials possess properties between metals and nonmetals and therefore they found various applications in the literature due to this property (Ali et al., 2017, Khan et al., 2017a). Semiconductor NPs possess wide bandgaps and therefore showed significant alteration in their properties with bandgap tuning. Therefore, they are very important materials in photocatalysis, photo optics and electronic devices.

5. Polymeric NPs

These are normally organic based NPs and, in the literature, a special term polymer nanoparticle (PNP) collective used for it. They are mostly nanospheres or nano capsular shaped (Mansha et al., 2017). The former are matrix particles whose overall mass is generally solid and the other molecules are adsorbed at the outer boundary of the spherical surface. In the latter case the solid mass is encapsulated within the particle completely (Rao and Geckeler, 2011). The PNPs are readily functionalize and thus find bundles of applications in the literature (Abd Ellah and Abouelmagd, 2016, Abouelmagdetal., 2016).

6. Lipid-based NPs

These NPs contain lipid moieties and effectively using in many biomedical applications. Generally, a lipid NP is characteristically spherical with diameter ranging from 10 to 1000 nm. Like polymeric NPs, lipid NPs possess a solid core made of lipid and a matrix contains soluble lipophilic molecules. Surfactants or emulsifiers stabilized the external core of these NPs (Rawat et al., 2011). Lipid nanotechnology (Mashaghietal., 2013) is a special field, which focus the designing and synthesis of lipid NPs for various applications such as drug carriers and delivery (Puri et al., 2009) and RNA release in cancer therapy (Gujrati et al., 2014).

BENEFITS OF NANOPARTICLES

Here are some of the benefits associated with nanotechnology:

Improved Materials

Nanomaterials can be stronger, lighter, and more durable than traditional materials. By tailoring material structures at extremely small scales, nanotechnology enhances properties such as strength, conductivity, and reactivity.

Everyday Commercial Products

Many everyday products already rely on nanoscale materials and processes:

- Can Eyeglasses and Displays: Clear nanoscale films on eyeglasses, displays, and windows make them water-repellent, antireflective, and resistant to UV or infrared light.
- Fabrics: Nanoscale sensors and electronics enable washable, durable "smart fabrics" for health Smart monitoring and energy harvesting.

  Fabrics: Nanoscale additives or surface treatments make fabrics lightweight, resistant to wrinkles, stains, and bacterial growth.
- Lightweighting: Nanoscale additives in composite materials contribute to lightweight, stiff, and resilient products like baseball bats, automobile parts, and power tool housings.

3. Health and Medicine

 Nanomedicine offers targeted drug delivery, imaging, and diagnostics at the cellular level.

 Nanoparticles can enhance cancer treatment by selectively targeting tumor cells.

 Biosensors based on nanotechnology enable rapid disease detection and monitoring.

4. Energy Efficiency

 Nanotechnology can improve energy storage, conversion, and distribution

 Lightweight materials reduce fuel consumption in transportation.

 Nanoscale solar cells and energy-harvesting devices enhance renewable energy sources

5. Envionmental conditions

 Nanotechnology contributes to water purification, air filtration, and pollution control.

 Nanoscale catalysts improve industrial processes and reduce emissions.

6. Food Safety and Agriculture

 Nanoscale sensors detect contaminants in food.

 Nanoparticles improve crop yield and nutrient absorption.

 Nanotechnology enhances food packaging and preservation

7. Infrastructure and Construction

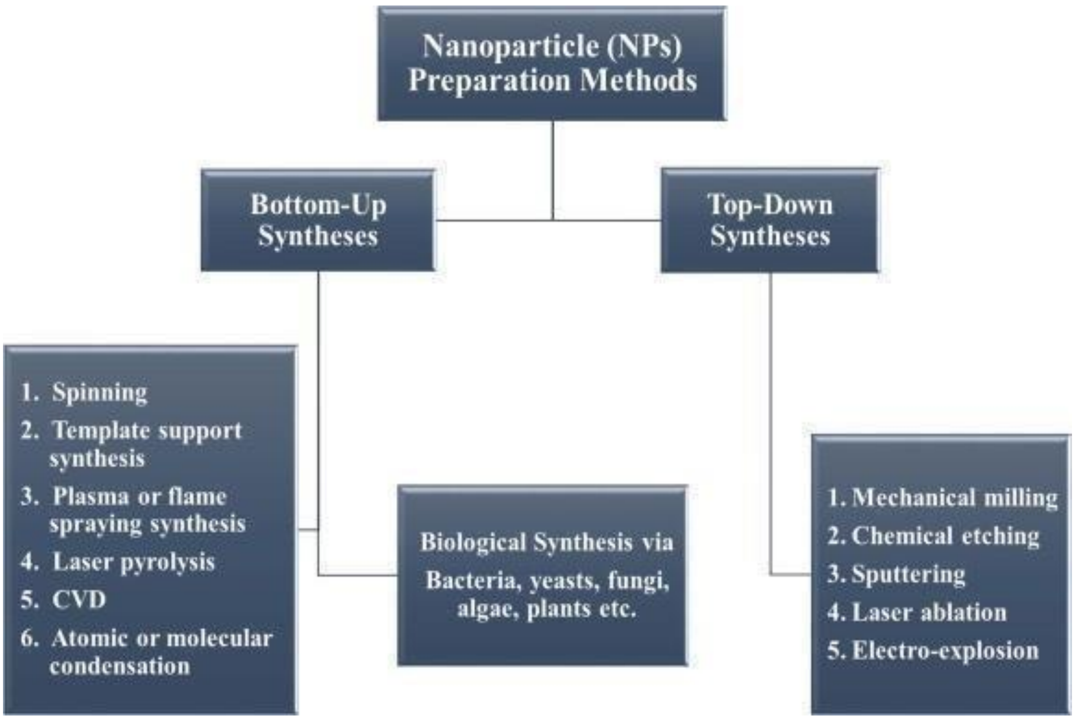
 Nanomaterials strengthen concrete, reduce corrosion, and improve durability.

 Self-healing materials repair cracks and damage.

 Nanotechnology contributes to large-scale infrastructure fabrication

SYNTHESIS OF NANOPARTICALS

Various methods can be employed for the synthesis of NPs, but these methods are broadly divided into two main classes i.e. (1) Bottom-up approach and (2) Top-down approach (Wang and Xia, 2004) as shown in Scheme 1 (Iravani, 2011). These approaches further divide into various subclasses based on the operation, reaction condition and adopted protocols.



Scheme 1: Typical synthetic methods for NPs for the (a) top-down and (b) bottom-up approaches.

1. Top-down syntheses

In this method, destructive approach is employed. Starting from larger molecule, which decomposed into smaller units and then these units are converted into suitable NPs. Examples of this method are grinding/milling, CVD, physical vapor deposition (PVD) and other decomposition techniques (Iravani, 2011). This approach is used to synthesized coconut shell (CS) NPs. The milling method was employed for this purpose and the raw CS powders were finely milled for different interval of times, with the help of ceramic balls and a well-known planetary mill. They showed the effect of milling time on the overall size of the NPs through different characterization techniques. It was determined that with the time increases the NPs crystallite size decreases, as calculated by Scherer equation. They also realized that with each hour increment the brownish color faded away due to size decrease of the NPs. The SEM results were also in an agreement with the Xray pattern, which also indicated the particle size decreases with time (Bello et al., 2015).

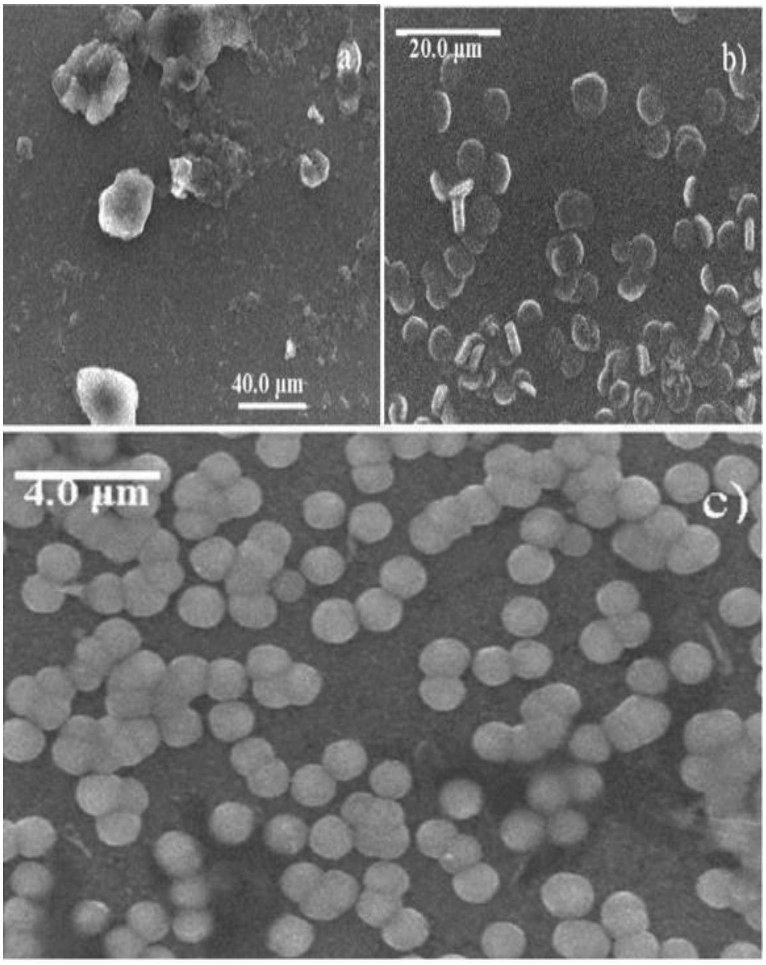
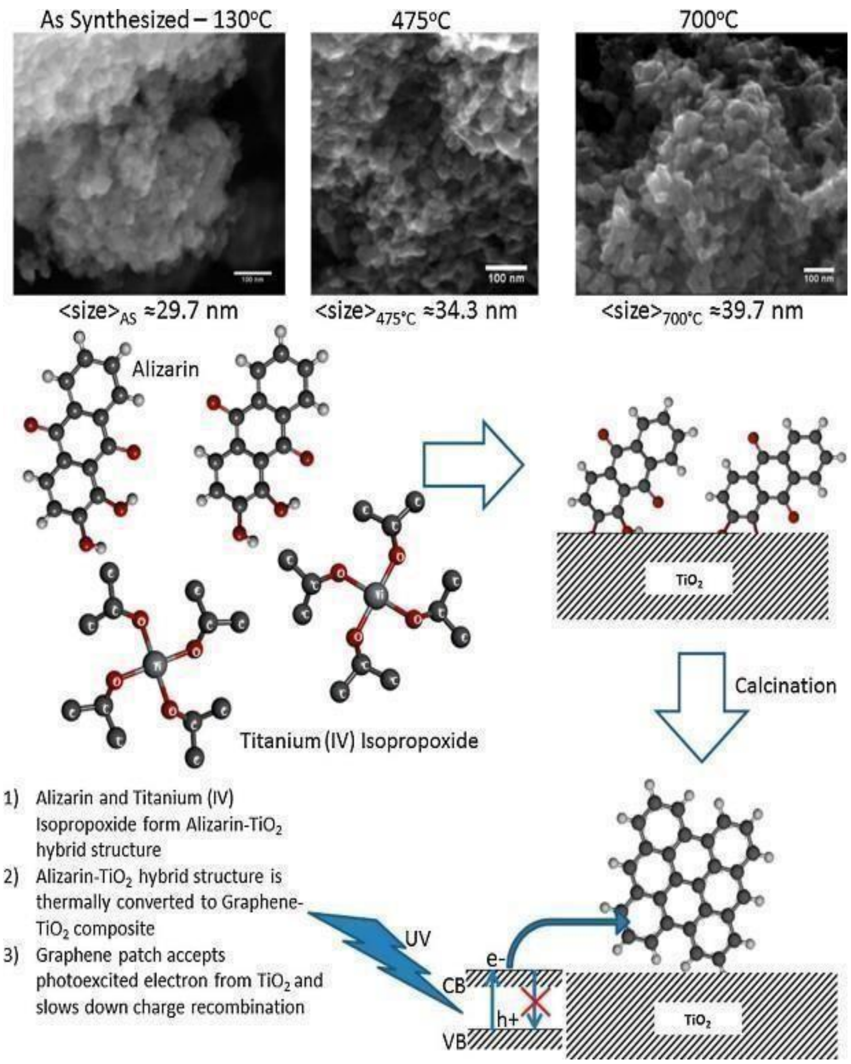


Figure 5: SEM images of (a) The untreated carbon black, (b) and (c) 10 min and 1 h ultrasonication in POM solution (Garrigue et al., 2004).

3.2. Bottom-Up synthesis

This approach is employed in reverse as NPs are formed from relatively simpler substances, therefore this approach is also called building up approach. Examples of this case are sedimentation and reduction techniques. It includes sol gel, green synthesis, spinning, and biochemical synthesis. (Iravani, 2011). Mogilevsky et al. synthesized TiO2 anatase NPs with graphene domains through this technique (Mogilevsky et al., 2014). They used alizarin and titanium isopropoxide precursors to synthesize the photoactive composite for photocatalytic degradation of methylene blue. Alizarin was selected as it offers strong binding capacity with TiO2 through their axial hydroxyl terminal groups. The anatase form was confirmed by XRD pattern. The SEM images taken for different samples with reaction scheme are provided in scheme 2. SEM indicates that with temperature elevation, the size of NPs also increases (Mogilevsky et al., 2014).



Scheme 2: Synthesis of TiO2 via bottom-up technique. SEM images showing the TiO2 NPs (Mogilevsky et al., 2014).

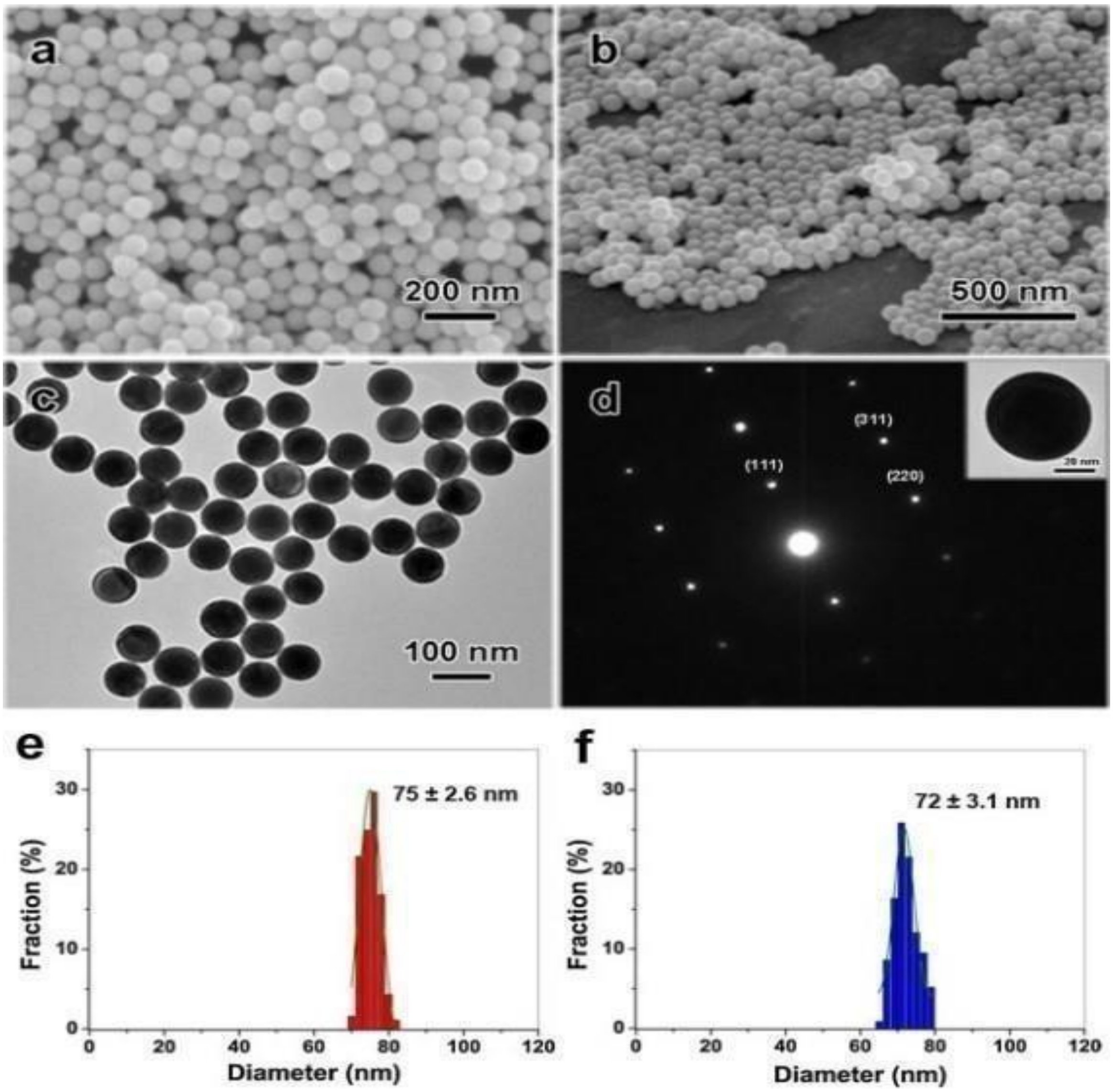


Figure 6: SEM for Au nanospheres (a) top view, (b) tilted view, (c) TEM image of Au nanospheres (d) SAED pattern (inset: TEM of single Au particle), (e) and (f) size distribution spectra of spherical and octahedral Au NPs (Liu et al., 2015a, Liu et al., 2015.

CHARACTERIZATION OF NANOPARTICLES

The physicochemical properties of nanoparticles are important for their behaviour, bio-distribution, safety, and efficacy. Therefore, characterization of nanoparticle is important in order to evaluate the functional aspects of the synthesized particles. Characterization is performed using a variety of analytical techniques, including UV-vis spectroscopy, X-ray diffractometry (XRD), Fourier transform infrared spectroscopy (FTIR), X-ray photoelectron spectroscopy (XPS), dynamic light scattering (DLS), scanning electron microscopy (SEM), transmission electron microscopy (TEM), and atomic force microscopy (AFM).

ANTI MICROBIAL ACTIVITY

Antimicrobial susceptibility testing can be used for drug discovery, epidemiology and prediction of therapeutic outcome. Antimicrobial technologies employed for preservation, disinfection, and sterilization are widely used for industrial and medical purposes in reducing or eliminating microorganisms. But in the development and application of these technologies, there are at least two major considerations: the desired antimicrobial effects (the most obvious reason behind employing these technologies) and safety requirements. Therefore, the objective of the desired end point with an antimicrobial process is important in its choice and application. This can range from the unique control of an individual type of microorganism (e.g., in a biosafety or research laboratory that may only be used for a certain type of microorganism), to the control of a range of potential pathogenic or spoilage microorganisms (e.g., in environmental disinfection requirements in food production, research laboratory, general microbiology detection laboratories, and health care facilities), and to the complete eradication of all types of harmful or product degrading microorganisms in higher risk situation (as during the administration of injectable drugs or surgical intervention with devices). Safety requirements will also vary depending on the use of the antimicrobial technology. These can include material compatibility, safety to those using the technology, safety to the end consumer or patient, and safety for the environment. They will also vary depending on the application such as in the preparation of food/water for consumption, treatment of Environmental surface, use on skin, mucous membranes or in wounds, productions to be placed or injected into the body or blood stream, or in other industrial situation such as during microelectronic manufacturing. Equally, the definition of these requirements and the risk benefit balance in each situation are important to consider.

INTRODUCTION TO SILVER NANOPARTICLES

Silver nanoparticles (AgNPs) are increasingly used in various fields, including medical, food, health care, consumer, and industrial purposes, due to their unique physical and chemical properties. These include optical, and thermal, high electrical conductivity, and biological properties. Due to their electrical peculiar properties, they have been used for several applications, including as antibacterial agents, in industrial, household, and healthcare-related products, in consumer products, medical device coatings, optical sensors, and cosmetics, in the pharmaceutical industry, the food industry, in diagnostics, orthopedics, drug delivery, as anticancer agents, and have ultimately enhanced the tum or killing effects of anticancer drugs. Recently, AgNPs have been frequently used in many textiles, keyboards, wound dressings, and biomedical devices. Nanosized metallic particles are unique and can considerably change physical, chemical, and biological properties due to their surface-to-volume ratio; therefore, these nanoparticles have been exploited for various purposes. In order to fulfil the requirement of AgNPs, various methods have been adopted for synthesis. Generally, conventional physical and chemical methods seem to be very expensive and hazardous. Interestingly, biologically-prepared AgNPs show high yield, solubility, and high stability.

The biological activity of AgNPs depends on factors including surface chemistry, size, size distribution, shape, particle morphology, particle composition, coating/capping, agglomeration, and dissolution rate, particle reactivity in solution, efficiency of ion release, and cell type, and the type of reducing agents used for the synthesis of AgNPs are a crucial factor for the determination of cytotoxicity. The physicochemical properties of nanoparticles enhance the bioavailability of therapeutic agents after both systemic and local administration and other hand it can affect cellular uptake, biological distribution, penetration into biological barriers, and resultant therapeutic effect. Recently, AgNPs have been shown much interest because of their therapeutic applications in cancer as anticancer agents, in diagnostics, and in probing.

DIFFERENT METHODS OF PREPARATION OF SILVER NANOPARTICLES

Preparation of sliver nano particles by using silver nitrate polyvinyl pyrrolidone and trisodium citrate

Preparation of silver nitrate solution

Take 100ml of beaker and wash the beaker with water for removal of previous experiment particles and place the T beaker in hot over. After washing allow water particles to evaporate in over.

Take 100ml of distilled water in a beaker

Weigh the 0.1gr of silver nitrate and add into the 100ml of distilled water mix it and keep it a side.

Preparation of polyvinyl pyrrolidone solution

Weigh the 0.5gr of polyvinyl pyrrolidone.

And mix into a 50ml of distilled water.

It should dissolve in a warm water and keep it a side.

Preparation of 1% trisodium citrate solution

Weight the 1gr of trisodium citrate

And mix it into a 100ml distilled water in beaker

Keep it a side

Preparation of silver nanoparticles

Take 100ml of beaker wash it and kept in a hot air oven.

Take the 20 ml of silver nitrate into the beaker of the prepared solution. And add the 10ml of polyvinyl pyrrolidone into the beaker.

Add 50ml of trisodium citrate from above the 1% solution.

Heat the mixed liquid beaker on hot plate unit the colour changed.

Take the beaker and add magnetic bead and kept it on magnetic stirrer with hot plate for few minutes

Make up to 100ml in a beaker the colour change is seen since it indicates the presence of silver nanoparticles

CONCLUSION

In this review, we presented a detail overview about NPs. Their types: synthesis, characterization, physiochemical properties and applications. Through different characterization techniques such as SEM, TEW and XRD, it was revealed that NPs have size range from few nanometre to 500 nm. While the morphology is also controllable. Due to their thin size, Nps have large surface area. Which make them suitable candidate for various applications. Beside this, the optical properties are also dominant at that size. Which further increase the importance of these materials in photocatalytic applications. Synthetic techniques can be useful to control the specific morphology, Size and magnetic properties of NPs. Though NPs are useful for many applications, but still there are some health hazard concerns due to their uncontrollable use and discharge to natural environment. Which should be consider for make the use of NPs more convenient and environmental friendly. Synthesis of nanoparticles by using chemicals like Tri-sodium citrate, silver nitrate are useful and these chemicals show good antimicrobial actions.

REFERENCES

1. Chen, X, Schluesener, H.J.: Nano silver: a nonproduct in medical application. Toxicol Lett., 2008; 176: 1-12. https://en.m.wikipedia.org/wiki/Nanoparticle

2. Nanoparticle classification, physicochemical properties, characterization, and application: a comprehensive review for biologists by Nadeem Joudeh & Dirk Linke. https://encyclopedia.pub/entry/29878
3. Antimicrobial activity of Silver Nanoparticles synthesized by using Medicinal Plants by N. Savithramma 1, M. Linga Rao.
4. Raji V, Chakraborty M, Parikh P, Synthesis of Starch-Stabilized Silver Nanoparticles and Their Antimicrobial Activity. Part Sci Technol, 2012; 30(60): 565-77. https://doi.org/10.1080/02726351.2011.626510.
5. Karwowska E. Antibacterial potential of nanocomposite-based materials-a short review. Nanotechnol Rev., 2016; 6(2): 243-54. https://doi.org/10.1515/ntrev-2016-0095.
6. V. Kumar, A. Vinod, and P. Savarimuthu, Sensors and Actuators B: Chemical, 2014; 91: 3136.
7. M. D. Malinsky k. L. Kelly G. C. Schatzand R. P. Van Duyne, J. AM. Chem. Soc., 123L: 1471-1482(20).
8. Muntha P. Pharmaceutical Nanotechnology Applications of Nanotechnology in Pharmaceutics. J Pharm Nanotechnol, 2016; 4(2): 1-7.
9. Zaed M. Amira M, Rasha S, Emad B. Ehab R. Pharmaceutical nanotechnology: from the bench to the market. Future J Pharm Sci., 2022; 8(12): 1-11.
10. Abou El-Nour KM, Eftaiha A, Al-Warthan A. Ammar RA. Synthesis and applications of silver nanoparticles. Arabian journal of chemistry, 2010; 3: 135-40.
11. Tarasenko N. Butsen A. Nevar E. Savastenko N. Synthesis of nanosized particles during laser ablation of gold in water. Applied surface science, 2006; 252: 4439-44.
12. Li D.G., Chen S.H., Zhao S.Y., Hou X.M., Ma H.Y., Yang X.G.. Thin Solid Films, 2004; 460: 78.
13. J. S. Kim, E. Kuk, K.N. Yu, JH. Kim, S.J. Park, H.J. Lee, and M.H. Cho, "Antimicrobial effects of silver nanoparticles", Nanomedicine: Nanotechnology, Biology and Medicine, 2007; 3(1): 95-101.
14. W.R. Li, X.B. Xie, Q.S. Shi, H.Y. Zeng, O.Y. You-Sheng, and Y.B. Chen, "Antibacterial activity and mechanism of silver nanoparticles on Escherichia coli", Applied microbiology and biotechnology, 2010; 85(4): 1115-1122.